**Remarks:**

1. Objections and Rejections.

Claims 6 and 16 stand rejected under 35 U.S.C. § 112, ¶1, as allegedly not being enabled by the specification, as filed. The drawings stand objected to as allegedly failing to show certain elements relating to a torque limiter. Moreover, claims 1, 5, 7, 8, 15, and 17 stand rejected under 35 U.S.C. § 102(b), as allegedly being anticipated by U.S. Patent No. 6,273,230 to Nakano et al. ("Nakano"). Applicant respectfully traverses.

2. 35 U.S.C. 112, ¶1.

Claims 6 and 16 stand rejected as allegedly not being enabled by the specification, as filed. The Office Action asserts that the above-captioned patent application "fails to disclose how the claimed invention would work with a torque limiter" and "fails to provide the elements of the torque limiter and how they would work with the described power transmission in order to limit the torque." Office Action, Page 3, Lines 11-13. Applicant respectfully traverses.

Applicant has amended the specification as indicated above. Thus, Applicant's specification, as amended, clearly recites that a torque limiter may comprise hub 4, damper 5, and connecting member 6. Applicant respectfully submits that those of ordinary skill in the art of the invention readily would understand Applicant's claimed invention, as set forth in claims 6 and 16, in view of Applicant's specification, as filed. For example, European Patent No. EP 0890760A2 to Koitabashi et al. ("Koitabashi") (copy enclosed) describes a torque limiter comprising an inner boss 7, an elastic ring 9, and an outer ring 5, and those of ordinary skill in the art readily would understand that hub 4, damper 5, and connecting member 6 substantially correspond to inner boss 7, elastic ring member 9, and outer ring 5, as described in Koitabashi

and as depicted in **Figs. 2A** and **6B** thereof.[1] In view of Applicant's specification, as filed, and known torque limiters, such as the torque limiter described in Koitabashi, those of ordinary skill in the art readily would understand how a drive mechanism operates in combination with a torque limiter. Therefore, Applicant respectfully requests that the Examiner withdraw the enablement rejections of claims 6 and 16.

3. Objections to the Drawings.

The Examiner objects to the drawings as allegedly failing to show a torque limiter, as set forth in claims 6 and 16. Applicant has amended the specification to indicate that a torque limiter may comprise elements 4, 5, and 6, which are depicted in **Fig. 1**, as set forth in claims 6 and 16. Elements 4, 5, and 6 were included in the drawings, as filed. Therefore, Applicant respectfully requests that the Examiner withdraw the objections to the drawings.

4. 35 U.S.C. § 102(b).

Claims 1, 5, 7, 8, 15, and 17 stand rejected as allegedly being anticipated by Nakano. "A claim is anticipated if and only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." MPEP 2131. The Office Action alleges that Nakano describes each and every element as set forth in claims 1, 5, 7, 8, 15, and 17. Applicant respectfully disagrees.

Independent claims 1 and 8 each describe a power transmission, comprising "a second rotating member connected to main shaft of a rotary apparatus; and a mechanism for engaging a plunger of said electromagnetic solenoid to and for disengaging said plunger from

[1] Other examples of torque limiters, as disclosed in U.S. Patent No. 6,425,837, U.S. Patent No. 6,494,799, and U.S. Patent App. No. 2003/0104890, were identified in the specification of the above-captioned patent application. One of ordinary skill in the art would understand that such torque limiters, or a torque limiter comprising hub 4, damper 5, and connecting member 6, are suitable for use in the claimed invention.

said second rotating member." (Emphasis added.) Thus, in Applicants' claimed invention, as set forth in independent claims 1 and 8, (a) the second rotating member is connected to a rotary apparatus, and (b) a mechanism selectively disengages the plunger from the second rotary apparatus.

The Office Action asserts that "Nakano discloses a power transmission comprising: a first rotating member (34,35) . . .; a second rotating member (unnumbered, See Fig 1) connected to a main shaft (39) of a rotary apparatus (compressor); and a mechanism (38) for engaging a plunger (37) of said electromagnetic solenoid to and for disengaging said plunger from said second rotating member." Office Action, Page 4, Lines 1-7. In **Fig. 1** of Nakano, the only element which is connected to main shaft 39 of the rotary apparatus is an unnumbered, L-shaped element which also is connected to mechanism 38 via a bolt (not numbered). (Emphasis added.) Therefore, Applicant understands that the Office Action is equating this unnumbered, L-shaped member to Applicant's second rotating member, as set forth in independent claims 1 and 8. Nevertheless, the unnumbered, L-shaped member is connected to mechanism 38 via a bolt, and mechanism 38 is connected to plunger 37 via a bolt. As such, plunger 37 is never disengaged from the unnumbered, L-shaped member which the Office Action asserts corresponds to Applicant's claimed second rotating member. (Emphasis added.) As such, the unnumbered, L-shaped member does not correspond to Applicant's claimed second rotating member. (Emphasis added.) Moreover, Applicant respectfully submits that rotor 35 also does not correspond to Applicant's claimed second rotating member because rotor 35 is not connected to main shaft 39. Therefore, Nakano fails to disclose each and every element of the claimed invention, and Applicant respectfully requests that the Examiner withdraw the anticipation rejection of independent claims 1 and 8.

Claims 5-7 and 15-17 depend from allowable, independent claims 1 and 8, respectively. Therefore, Applicant respectfully requests that the Examiner also withdraw the anticipation rejections of claims 5, 7, 15, and 17.

**Conclusion:**

Applicant respectfully submits that this application, as amended, is in condition for allowance, and such disposition is earnestly solicited. If the Examiner believes that an interview with Applicant's representatives, either in person or by telephone, would expedite prosecution of this application, we would welcome such an opportunity. Applicant believes that no fees are due as a result of this responsive amendment. Nevertheless, in the event of any variance between the fees determined by Applicant and the fees determined by the U.S. Patent and Trademark Office, please charge or credit any such variance to the undersigned's Deposit Account No. 02-0375.

Respectfully submitted,
BAKER BOTTS L.L.P.

Dated: May 22, 2006

By: ______________________
James B. Arpin
Registration No. 33,470

Baker Botts L.L.P.
The Warner; Suite 1300
1299 Pennsylvania Avenue, N.W.
Washington, D.C. 20004-2400
(202) 639-7700 (telephone)
(202) 639-7890 (facsimile)

JBA/djw

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(71) Applicant: Sanden Corporation
Isesaki-shi, Gunma 372-8502 (JP)

(72) Inventor: Koitabashi, Takatoshi
Isesaki-shi, Gunma, 372/8502 (JP)

(74) Representative:
Prüfer, Lutz H., Dipl.-Phys. et al
PRÜFER & PARTNER GbR,
Patentanwälte,
Harthauser Strasse 25d
81545 München (DE)

(54) **Power transmission mechanism having an elastic ring member compressed between an outer ring and an inner boss**

(57) For transmitting a power between a driving member such as a pulley (3) and a driven member such as a shaft (6) of a compressor, an elastic member (9) is placed between an outer ring (5) fixed to the driving member and an inner boss (7) fixed to the driven member with being compressed between the outer ring and the inner boss. The torque of the driving member is transmitted to the driven member through the outer ring, the elastic member, and the inner boss. When the driven member is locked to be unable to rotate, slips are generated between the outer ring and the elastic member. The slips result in generating a frictional heat, so that the elastic member is fused due to the friction heat to instantly shut off the power transmission.

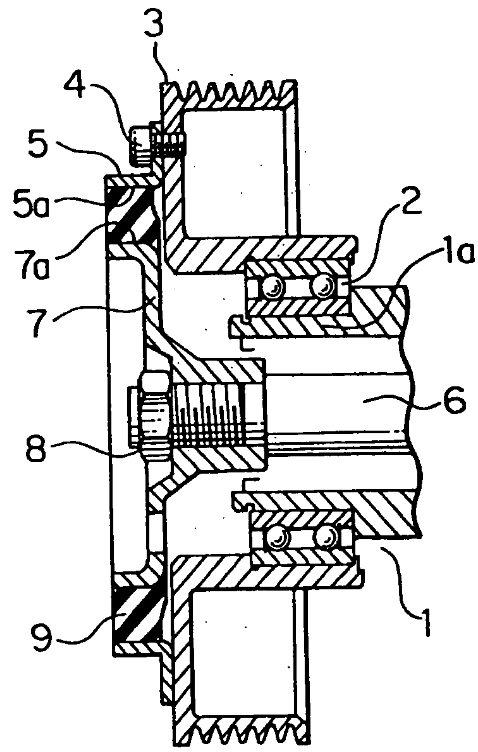


FIG. 2B

EP 0 890 760 A2

## Description

### Background of the Invention:

The present invention relates to a power transmission mechanism having a torque limiter function, which can be widely used in the fields of compressors and other general industrial devices.

There have been proposed various power transmission mechanisms of this type. As an example, a conventional power transmission mechanism is described in JP-A-8-135752. The conventional power transmission mechanism is used in a compressor and is for transmitting a power from a driving member or a pulley to a driven member or a shaft of the compressor.

The conventional power transmission mechanism comprises a first retaining member of a ring shape fixed to the driving member, a second retaining member of the ring shape placed concentric with the first retaining member and fixed to the driven member, and an elastic ring member inserted between the first and the second retaining members. Each of the first and the second retaining members has a plurality of convex portions and concave portions. On the other hand, the elastic ring member has a plurality of convex portions and concave portions which are engaged with the convex portions and the concave portions of each of the first and the second retaining members in a rotation direction to transmit the power from the driving member the driven member.

Upon generation of the torque exceeding a set value due to seizure of the compressor or the like, the elastic ring member is deformed to reduce its thickness in radial directions thereof. As a result, the elastic ring member causes slips relative to the concave portions and convex portions of the second retaining member so that the transmission of the torque is precluded.

In the conventional power transmission mechanism, even if the elastic ring once slips to cause its convex and concave portions to escape from the concave and convex portions of the second retaining member, it is likely that they are caught in the adjacent concave and convex portions of the second retaining member to again transmit the torque.

Further, for the elastic ring to reduce the radial thickness thereof in response to a small pressing force, the hardness of the elastic ring needs to be lessened. On the other hand, for the convex and concave portions of the elastic ring to endure the local repetitive compression, the hardness thereof needs to be enlarged. Thus, if the durability is given priority, that is, if the hardness is increased, the transmission shut-off torque is rendered increased so that the reliability as a protective function is lowered.

Further, upon assembling the elastic ring and the first and second retaining members, it is necessary to precisely match the concave and convex portions so that positioning thereof is complicated.

### Summary of the Invention:

It is therefore an object of the present invention to provide a power transmission mechanism in which a torque transmission can be reliably shut off on exceeding a set value.

It is another object of the present invention to provide a power transmission mechanism of the type described, in which durability is improved.

It is still another object of the present invention to provide a power transmission mechanism of the type described, in which generation of noise and vibration can be prevented upon the shut-off of the torque transmission.

It is yet another object of the present invention to provide a power transmission mechanism of the type described, in which the number of parts is reduced so that assembling is simplified and can be readily carried out.

Other object of the present invention will become clear as the description proceeds.

A power transmission mechanism to which the present invention is applicable is for transmitting a power between a driving member and a driven member. The power transmission mechanism comprises an outer ring fixed to the driving member and having an inner circular surface, an inner boss fixed to the driven member and having an outer circular surface which is opposite to the inner circular surface in a radial direction of the outer ring to form a ring-shaped space therebetween, and an elastic member placed in the ring-shaped space. In the power transmission mechanism, the elastic member is compressed in the radial direction to generate a compressive reaction which makes the elastic member become in press contact with the inner and the outer circular surfaces.

### Brief Description of the Drawing:

Figs. 1A and 1B show the main portion of a compressor having a conventional power transmission mechanism, wherein Fig. 1A is a front view, Fig. 1B being a sectional view taken along line A-O-A in Fig. 1A;

Figs. 2A and 2B show the main portion of a compressor having a power transmission mechanism according to a first preferred embodiment of the present invention, wherein Fig. 2A is a front view, Fig. 2B being a sectional view;

Fig. 3 is a perspective view of the power transmission mechanism illustrated in Figs. 2A and 2B;

Fig. 4 is a perspective view showing a press-fitting process of the power transmission mechanism illustrated in Figs. 2A and 2B;

Fig. 5 is a graph showing a relationship between contraction or fitting margin and transmission shut-off torque in the power transmission mechanism illustrated in Figs. 2A and 2B;

Figs. 6A and 6B show the main portion of a compressor having a power transmission mechanism according to a second preferred embodiment of the present invention, wherein Fig. 6A is a front view, Fig. 5B being a sectional view;

Fig. 7 is a partial development view of an outer ring included in a power transmission mechanism according to third preferred embodiment of the present invention; and

Fig. 8 is an exploded perspective view of a power transmission mechanism according to a fourth preferred embodiment of the present invention.

Description of the Preferred Embodiment:

Referring to Figs. 1A and 1B, the conventional power transmission mechanism will be described for a better understanding of the present invention. The conventional power transmission mechanism corresponds to that is described in JP-A-8-135752. An inner ring of a bearing 24 is fixed to a tubular projection 22A of a front housing 22 of a compressor 21, and a rotor 25 is fixed to an outer ring of the bearing 24. A pulley 26 is fixed to the rotor 25, and a first retaining member 28 is fixed to the pulley 26 by rivets 27. A hub 29 is fixed to a shaft 23 of the compressor 21 by means of a nut 30, and a second retaining member 32 is fixed to the hub 29 by rivets 31. An elastic ring member 33 is inserted between the first retaining member 28 and the second retaining member 32.

The elastic ring member 33 has a petal shape and is formed at its inner and outer circumferences with a plurality of convex portions 33a and concave portions 33b. The first retaining member 28 is formed at its outer circumference with a plurality of concave portions 28a and convex portions 28b corresponding to the plurality of convex portions 33a and concave portions 33b of the elastic ring member 33, respectively. Further, the second retaining member 32 is formed at its inner circumference with a plurality of concave portions 32a and convex portions 32b corresponding to the plurality of convex portions 33a and concave portions 33b of the elastic ring member 33, respectively.

During a normal operation, the plurality of convex portions 33a and concave portions 33b of the elastic ring 33 are subjected to compressive deformation between the plurality of concave portions 28a and convex portions 28b of the first retaining member 28 and the plurality of concave portions 32a and convex portions 32b of the second retaining member 32 so that the torque is transmitted from the pulley 26 to the shaft 23 of the compressor 21 due to the reaction of the elastic ring member 33. Upon generation of the torque exceeding a set value due to seizure of the compressor 21 or the like, the elastic ring member 33 is deformed to reduce its thickness in radial directions thereof. As a result, the elastic ring member 33 causes slips relative to the concave portions 32a and convex portions 32b of the second retaining member 32 so that the transmission of the torque is precluded.

Referring now to Figs. 1A, 1B, and 2, description is made as regards a power transmission mechanism according to a first preferred embodiment of the present invention. The power transmission mechanism is used in a compressor having a front housing 1 and a shaft 6. In the manner known in the art, the compressor carries out compressing operation as regards a gaseous fluid when the shaft 6 is rotated. For rotating the shaft 6, the power transmission mechanism transmits a power from a driving member or a pulley 3 to a driven member or the shaft 6.

The pulley 3 is rotatably supported on the front housing 1 through a bearing 2. More particularly, the bearing 2 comprises an inner ring fixed to a tubular projection 1a of the front housing 1 and an outer ring fixed to the pulley 3.

The power transmission mechanism comprises an outer ring 5, an inner boss 7, and an elastic ring member 9. The outer ring 5 is fixed to the pulley 3 by means of three bolts 4 and has an inner circular surface 5a. The inner boss 7 is fixed to the shaft 6 by a nut 8 and has an outer circular surface 7a which is opposite to the inner circular surface 5a in a radial direction of the outer ring 5 to form a ring-shaped space therebetween. The elastic ring member 9 is placed in the ring-shaped space and circularly extends to form a ring shape. More particularly, the elastic ring member 9 is vulcanization-adhered around the outer circular surface 7a of the inner boss 7 and is press-fitted in the outer ring 5. The elastic ring member 9 is made of rubber known in the art.

For the press-fitting, a method is adopted wherein an outer diameter of the elastic ring member 9 is set to be slightly greater than an inner diameter of the outer ring 5, that is, a fitting margin is provided, and then the elastic ring member 9 is press-fitted in the outer ring 5.

Referring to Figs. 4, the description will be made as regards another method of the press-fitting. In this method, after integral formation of the outer ring 5, the inner boss 7 and the rubber elastic ring 9, an outer diameter of the outer ring 5 is reduced by a contraction process. This method can provide uniform radial contraction margins.

Specifically, the inner boss 7 applied with an adhesive on its outer circumference and the outer ring 5 are set in a rubber vulcanization die, and then melted rubber is injected into the die so that the inner boss 7 is subjected to vulcanization adhesion. In this event, the inner circumference of the outer ring 5 is in contact with the rubber, but does not adhere thereto.

Then, using a contraction jig 11, the outer diameter of the outer ring 5 is reduced. Since a guide diameter D1 of the contraction jig 11 is set greater than an outer diameter D0 of the outer ring 5 after the vulcanization (D1>D0) to provide a proper clearance therebetween, galling between the contraction jig 11 and the outer ring

5 is not caused.

The contraction jig 11 is provided with a tapered outer circumference 11a and further provided with slits 11b arranged at regular intervals in a circumferential direction thereof to provide split pieces 11c. Accordingly, when a punch 13 is lowered to press the rubber assembly 10 and the contraction jig 11 into a presser jig 12 having a tapered inner circumference 12a, the split pieces 11c are forced inward to press the outer ring 5 so as to have a required diameter D2 (see Fig. 3). This causes the elastic ring member 9 to generate the uniform compressive reaction.

Following upward movement of the punch 13 after the completion of the contraction process, the contraction jig 11 supported by a spring (not shown) is also raised. In this event, since the contraction jig 11 is made of spring steel or the like, the split pieces 11c are restored to the original diameter D1. As appreciated, the contraction margin is given by D0-D2.

Referring to Fig. 5, the description will be directed to a relationship between the contract margin or the fitting margin and the transmission shut-off torque. When the transmission torque becomes about 6 to 7kgfm, a driving belt of the pulley 3 starts slipping. Accordingly, in this embodiment, setting the maximum shut-off torque to 6kgfm, a contact area between the outer ring 5 and the elastic ring member 9 was set and then a corresponding proper contraction or fitting margin was determined. Since the sufficient safety factor should be ensured relative to the normal load torque of the compressor, the minimum transmission torque was set to 4.5kgfm. Accordingly, the proper contraction or fitting margin was found to be 5 to 10%.

The torque of the pulley 3 is transmitted to the shaft 6 of the compressor via the outer ring 5, the elastic ring member 9 and the inner boss 7 by means of a frictional force determined by an internal compressive reaction and a friction coefficient of the elastic ring member 9. The torque fluctuation during the normal load is relaxed by means of the elastic ring member 9.

The internal compressive reaction of the elastic ring member 9 is uniform along the entire contact surface of the outer ring 5, and further, the outer ring 5 has no geometrically constrained portions. Thus, the shut-off torque can be held constant.

If the load torque of the compressor increases to approach a set value of the shut-off torque, the frictional force generated between the inner circumference of the outer ring 5 and the outer circumference of the rubber elastic ring 9 can not overcome the torque so that slips are caused. However, due to the rigidity of the elastic ring member 9, slipping and non-slipping are alternately repeated.

Then, when the compressor is locked to be unable to rotate, slips are generated between the outer ring 5 and the elastic ring member 9 so that the rubber is fused by generated frictional heat to immediately shut off the torque transmission. Therefore, damage to the driving belt of the pulley 3 is prevented.

Turning to Figs 6A and 6B, the description will be made as regards a power transmission mechanism according to the second preferred embodiment of the present invention. The power transmission mechanism comprises similar parts designated by like reference numerals.

In the power transmission mechanism, the pulley 3 has an axial end 3a facing the ring-shaped space that is remained between the outer ring 5 and inner boss 7 in the radial direction. The elastic ring member 9 is in press contact with the axial end 3a of the pulley 3. In other words, the elastic ring member 9 has an axially projected portion 9a confronting the axial end 3a of the pulley 3 and has a part 9b interposed between the pulley 3 and the inner boss 7. With this structure, since the vibration and rotation run-out are absorbed, the durability is improved.

Referring to Fig. 7 together with Figs. 2A and 2B, the description will be made as regards a power transmission mechanism according to a third preferred embodiment of the present invention. The power transmission mechanism comprises similar parts designated by like reference numerals.

In the power transmission mechanism, the inner circular surface 5a of the outer ring 5 is formed with fine concave and convex portions 13 by shot blasting or knurling processing known in the art, and then are brought in press contact with the elastic ring member 9. Accordingly, the elastic ring member 9 is formed with convex portions and concave portions at an outer peripheral surface thereof. This results in cooperatively providing the fine concave/convex coupling between the outer ring 5 and the elastic ring member 9.

Accordingly, slips can be easily prevented by means of the fine concave/convex coupling. Further, when the compressor is locked to be unable to rotate, since the abrupt torque is applied to the roots of the fine rubber convex portions, the rubber convex portions are instantly sheared to shut off the torque transmission.

Referring to Fig. 8, the description will be made as regards a power transmission mechanism according to the fourth preferred embodiment of the present invention.

In the power transmission mechanism, an outer ring 5 is formed with an inward flange 5b which inwardly extends to face the above-mentioned ring-shaped space and has a plurality of ring-side engaging portions 5c. The elastic ring member 9 has a plurality of member-side engaging portions 9c at an axial end thereof. The member-side engaging portions 9c are engaged with the ring-side engaging portions 5c when the elastic ring member 9 is press-fitted into the outer ring 5. Through engagement between the engaging portions 5c and 9c, slips can be prevented more reliably. Since each of the engaging portions 5c has a hollow trapezoidal shape in section while each of the engaging portions 9c has a solid trapezoidal shape in section, the trans-

mission shut-off torque is not increased. Specifically, the principal torque transmission is carried out between the inner surface 5a of the outer ring 5 and the outer surface of the elastic ring member 9, while small slips can be prevented between the engaging portions 5c of the outer ring 5 and the engaging portions 9c of the elastic ring member 9.

While the present invention has been described in terms of the preferred embodiments, the invention is not to be limited thereto, but can be embodied in various ways without departing from the principle of the invention as defined in the appended claims.

## Claims

1. A power transmission mechanism for transmitting a power between a driving member and a driven member, comprising:

    an outer ring fixed to said driving member and having an inner circular surface;
    an inner boss fixed to said driven member and having an outer circular surface which is opposite to said inner circular surface in a radial direction of said outer ring to form a ring-shaped space therebetween; and
    an elastic member placed in said ring-shaped space, said elastic member being compressed in said radial direction to generate a compressive reaction which makes said elastic member become in press contact with said inner and said outer circular surfaces.

2. A power transmission mechanism as claimed in claim 1, wherein said elastic member circularly extends along said ring-shaped space to form a ring shape.

3. A power transmission mechanism as claimed in claim 1 or 2, wherein said elastic member is made of rubber.

4. A power transmission mechanism as claim in one of claims 1 to 3, wherein said elastic member is adhered to said outer circular surface of the inner boss.

5. A power transmission mechanism as claimed in one of claims 1 to 4, wherein said compressive reaction is determined to slide said elastic member slide along said inner circular surface of said driving member when said driving member has a torque exceeding a set value which is set for a power transmission between said driving and said driven members.

6. A power transmission mechanism as claimed in one of claims 1 to 5, wherein said outer ring and said elastic member generate frictional heat therebetween when said elastic member slides along said inner circular surface of said driving member, said frictional heat making said elastic member be fused at a portion adjacent to said inner circular surface so as to shut off said power transmission.

7. A power transmission mechanism as claimed in one of claims 1 to 6, wherein said driving member comprises a pulley having an axial end facing said ring-shaped space, said elastic member being in contact with said axial end of the pulley.

8. A power transmission mechanism as claimed in one of claims 1 to 7, wherein said inner circular surface of the outer ring is formed with a plurality of fine concave and convex portions which are engaged with said elastic member in a circumferential direction of said outer ring.

9. A power transmission mechanism as claimed in one of claims 1 to 8, wherein said outer ring includes an inward flange which inwardly extends to face said ring-shaped space and has a ring-side engaging portion, said elastic member having member-side engagging portion which engages with said ring-side engaging portion in a circumferential direction of said outer ring.

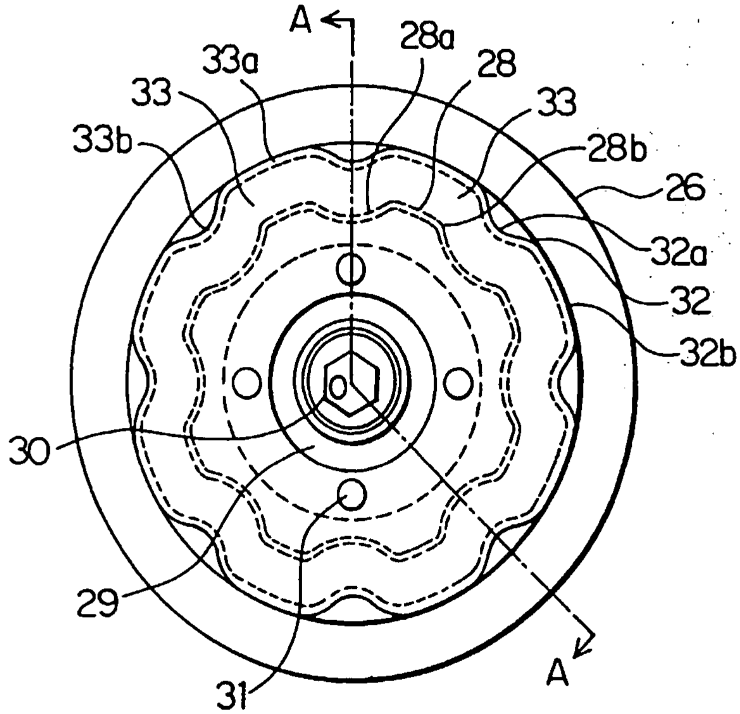


FIG. 1A PRIOR ART

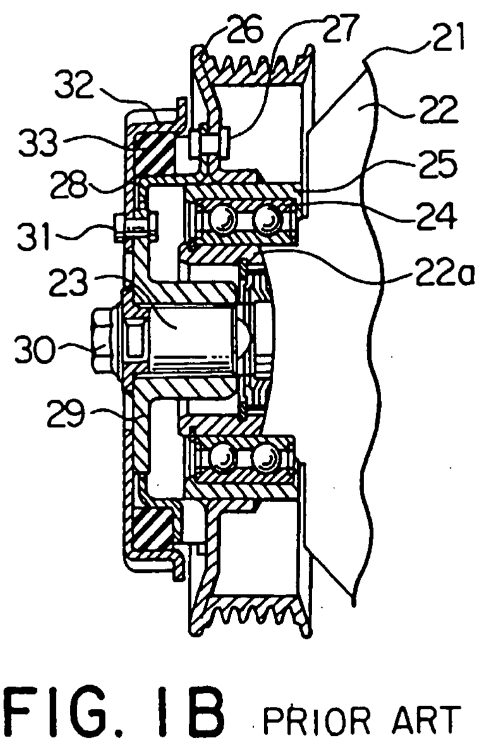


FIG. 1B PRIOR ART

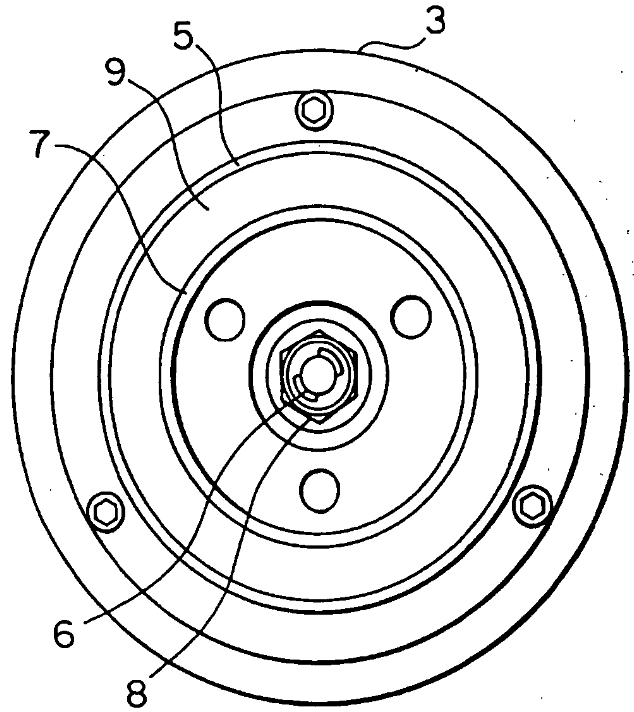


FIG. 2A

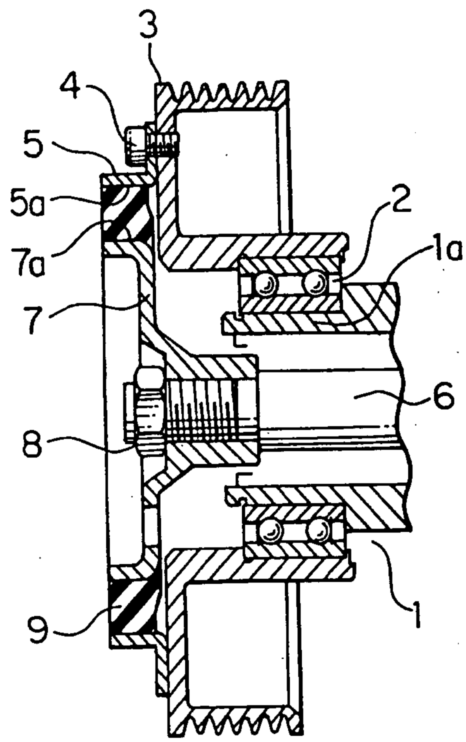


FIG. 2B

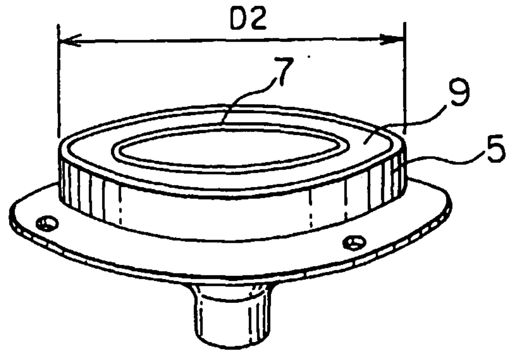


FIG. 3

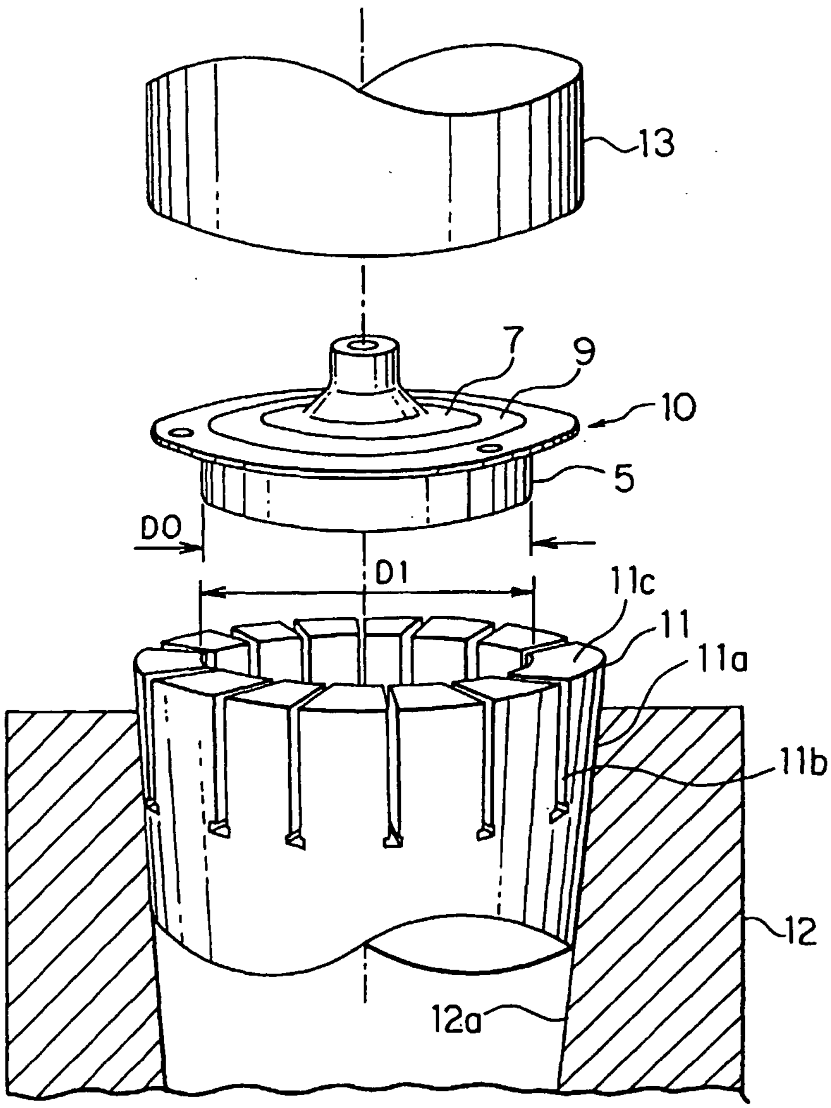


FIG. 4

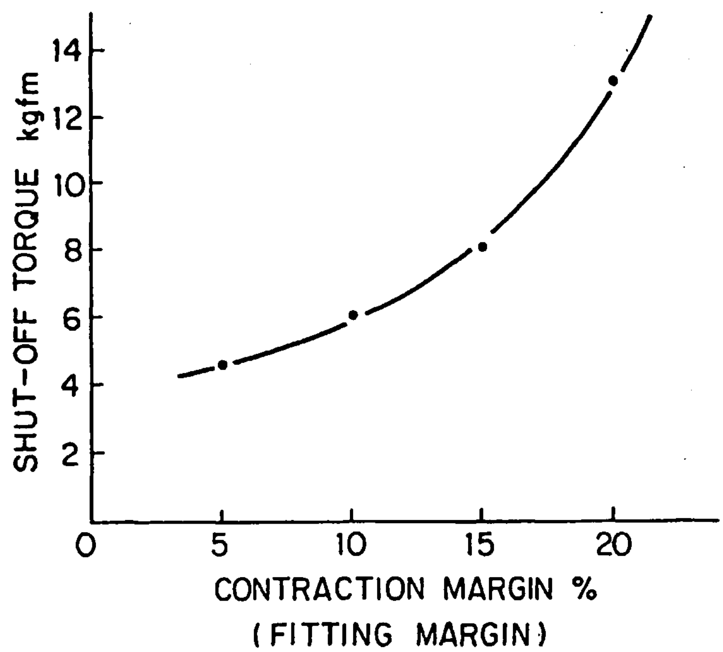
SHUT-OFF TORQUE kgfm
14
12
10
8
6
4
2
0
5
10
15
20
CONTRACTION MARGIN %
(FITTING MARGIN)

FIG. 5

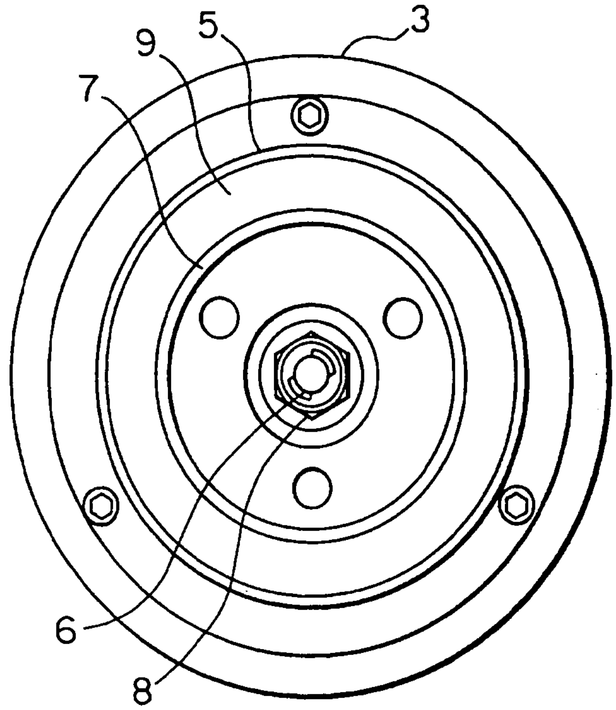


FIG. 6A

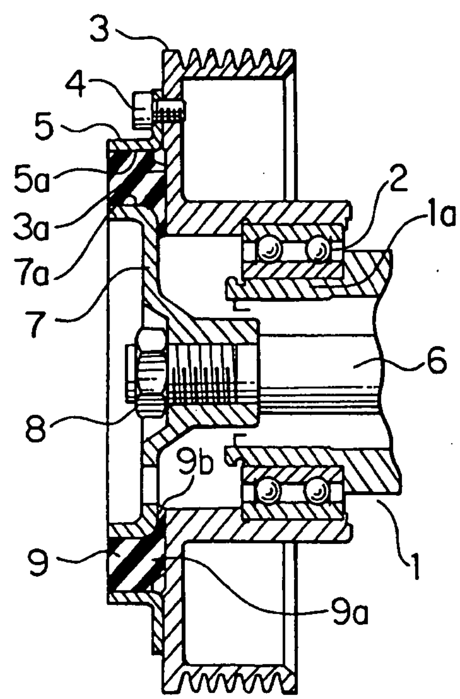


FIG. 6B

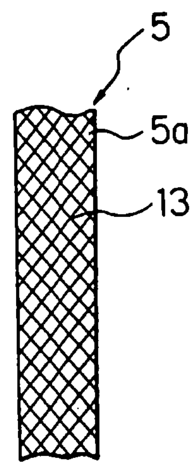


FIG. 7

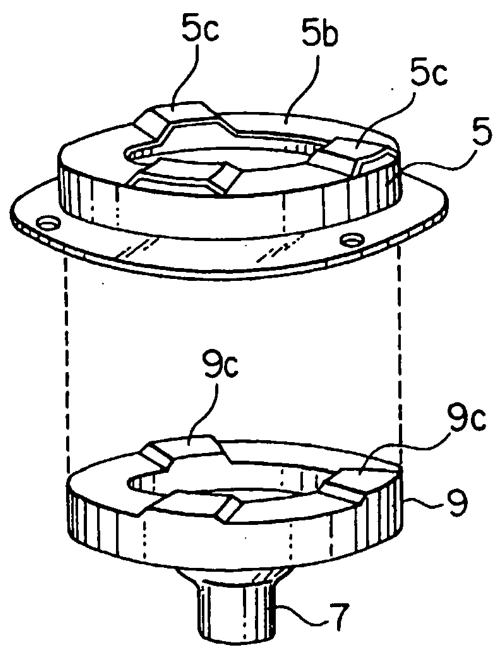


FIG. 8